Overview of this workshop

8 Sep 2005

LaFonda Hotel

Santa Fe, NM

Santa Fe room

Refreshments, breaks, wireless, parking

Abstract

Microfabrication for Quantum Physics, Plasma Physics, and Biophysics Applications

ADWP Strategic Initiative in Small Science

Tom Intrator, P-24 Plasma Physics, LANL

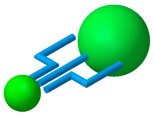
We describe a nascent Research/Program Focus Area that is the focus of collaborations between LANL, Sandia, academia, and industry. There is an Opportunity, Need, and Problem to be Solved. Next-generation electromechanical fabrication using LANL and SNL micro- and nano- scale fabrication capabilities could revolutionize key applications in Quantum Physics, Plasma Physics, and Biophysics

Quantum Physics: Microfabrication could revolutionize ion trapping, entangled photon production, and other technologies used for Quantum Simulation (QS), Quantum Computing (QC), Bose-Einstein Condensate (BEC) Interferometry, and Quantum Key Distribution (QKD). Would stimulate new algorithms for security of realistic entangled-state QKD and for entangled-state cryptographic protocols for applications beyond QKD.

Plasma Physics: Microfabrication of MHz bandwidth nano-sensors for Electric (E) and Magnetic (B) fields could provide unprecedented fine spatial resolution for measurements of strongly-coupled plasmas (as well as for Quantum applications above. Would bridge the gap between kinetic and fluid pictures, bridge multiple length scales, and enable new validations of code predictions.

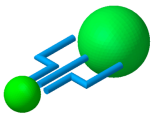
Biophysics: Microfabrication of electrode arrays and enhanced large-scale models could substantially advance the DOE-led consortium to build an Artificial Retina to restore sight to the blind. The same models would advance fundamental understanding of neural networks and lead to novel information-processing solutions to national security problems. Microfabrication and associated modeling would revolutionize microfluidics-based sensors for biomolecules labeled with magnetic nanoparticles.

Nano Gadget Workshop 2005



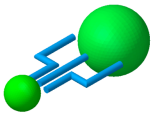
- Why are we here?
- LANL strategic initiative in small science
- Showcase efforts and resources
  - Sandia National Laboratory
  - Los Alamos National Laboratory
  - Academic partnerships - e.g. UCLA
- Strategies for the future

Microfabrication applications



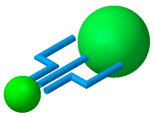
- Sponsor: ADWP - Associate Director Weapons Physics
  - Quantum physics
    - D. Berkeland, M. Boshier
  - Plasma Physics
    - T.Intrator, L. Dorf, Z .Wang, C. Ticos
  - Biophysics
    - J. George, J. Maxwell, M. Espy, C.C.Wood
- Research & program focus
  - To make revolutionary advances in quantum, plasma, bio physics
  - Combine micro fab & large scale computational models to overcome key technical challenges

Opportunity, need & problem to solve



- Next generation electro mechanical fabrication
  - Quantum physics
    - Ion trapping, entangled photon production
    - Technologies used for quantum simulation, quantum computing, Bose Einstein Condensate inteferometry, quantum key distribution (QKD), entangled state cryptographic protocols beyond QKD
  - Plasma Physics
    - MHz bandwidth E, B field sensors, fine spatial resolution for strongly coupled plasmas, bridge the gap between kinetic and fluid pictures, multiple length scales, validate code predictions
    - Quantum trap applications

Opportunity, need & problem to solve



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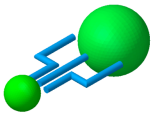
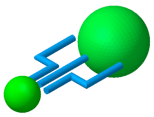
- Next generation electro mechanical fabrication …
  - Biophysics
    - Microfabrication of electrode arrays to advance DOE led consortium to build an Artificial Retina
    - Advance understanding of neural networks, information processing
    - Micro fluidic sensors for biomolecules

Investment questions & answers



- What are we trying to do?
  - Electro mechanical fabrication at micro and nano scales is a common enabling technology
    - Profound impact across a wide range of ADWP scientific and technical programs
    - Cross cutting technology = opportunity for Institutional Program Development
- Why will we succeed?
  - Strong track records of investigators, collaborators
  - Broad institutional value of this initiative

Investment questions & answers



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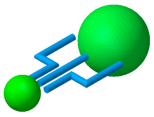
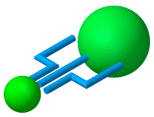
- What are today's solutions to these problems?
  - Ion traps are fabricated as one or several, limited scale up ability
  - Plasma diagnostics are macro scale, spatially integrate the micro physics
  - Retinal electrode arrays are limited in resolution, models are limited in scope
- What are the limitations and opportunities?
  - Nascent ideas on hand
  - Need workshops, proposal writing, sponsor contacts

Overall objectives, link to lab missions



- Biophysics
  - Leveraging LANL scientific and technical resources to U.S. health and environment are key elements of DOE & LANL charter
  - Proposed nano & micro scale fabrications enhance contributions to key bio medical problems, leadership for major DOE initiatives
- Quantum physics
  - Quantum computing, cryptography, simulation are transformational technologies for US national security, LANL mission
    - QuantumInformation Science and Technology Roadmap (http://qist.lanl.gov)

Overall objectives, link to lab missions



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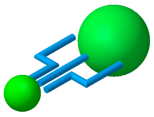
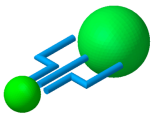
- Plasma physics
  - Detailed quantitative measurements of strongly coupled plasmas essential for predictive science, LANL nuclear weapons mission
  - Proposed nano & micro scale **E**, **B** sensors offer unprecedented spatial resolution, huge spatial scale range, validation of LANL nuclear weapons codes.

Benefits to LANL



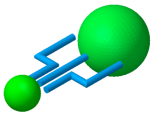
- Quantum Physics
  - Enable LANL and SNL partners to compete effectively in NSA's Research and Development Activity (ARDA) competition to build ion traps for quantum computation.
    - Industrial scal ion trap "foundry" would substantially advance quantum compputing, a major ARDA goal
    - Maintain LANL leadership in QKD
- Plasma Physics
  - Nano-based sensors with unprecedented resolution will allow detailed quantitative measures for validation of predictive science theory. Sponsors (NNSA and Office of Science) will choose LANL for future research.
  - Collaborations with SNL will benefit both LANL and SNL.

Benefits to LANL



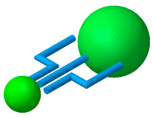
- Biophysics
  - Will maintain and advance LANL's role in a major DOE/BER initiative having great public exposure and perceived value.
  - Will ensure LANL leadership in new approaches to neurally-based information processing for important national security applications

SWOT Analysis summary



Strengths	Weaknesses
• We have already developed many of the "good ideas" essential for success • We have demonstrated technical capabilities and successes • Needed collaborations and partnerships already underway	• We do not have all needed capabilities in-house • We sometimes exhibit "not-invented here" syndrome
Opportunities	**Threats**
• Major sponsor demand (Intel Community, DOE/NNSA, DOE/SC, NIH, DARPA) • Open BAAs, RFAs, RFPs, and extensions of on-going projects	• Some university competitors are cheaper • Some university/industrial competitors are more effective and nimble as "prime contractors" for large, multi-institutional initiatives

Summary



- Cross fertilization among a wide spectrum of efforts
- Learn about the community resources
- Path forward for the future?
- Enjoy the presentations